Predicting Accident Trends and Traffic Improvement

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The traffic death rates per 100 million miles vehicular travel as used in this study are those published by the National Safety Council for 1935 to 1954, inclusive. A wide range in rates prevails yearly, as well as from year to year, for the individual states during this time.

By taking account of such trends for individual states, for groups of states, or for the country as a whole, it should be possible to evaluate the results of different types of road building programs, of enforcement policies, of educational efforts and other variables. This paper is presented as a pilot study in the area of accident-trend analysis.

Iowa and the total U. S. rates were chosen as those to be extrapolated for ten years hence. Linear, logarithmic and reciprocal time series trends were calculated for each of the two areas of study.

In the calculations of the linear regression trend extrapolations, a zero value is reached during 1978 for Iowa. Because the linear regression trend for the total U. S. rate is much steeper, a zero value is reached in 1968. This seems untenable; therefore, other assumptions were used.

The equation of a straight line admits of no irreducible minimum. To avoid such an assumption a logarithmic curvilinear relationship was considered whereby an irreducible minimum was determined. The method of arriving at this value was by using one-half of the average traffic death rate for the last ten years recorded. The value for Iowa was 3.2. This rate value was then held constant for the calculation of a logarithmic trend for the full period under study. The irreducible minimum calculated by this method for the total U. S. gave a much higher figure, 4.1.

The prediction of traffic death rates should not exceed a period of more than 10 years for practical purposes. If at that time, or at an intervening year, unforseen events (such as a war or economic recession) cause drastic fluctuations, a recalculation should be made prior to the end of the original decade. It is possible that calculations on the basis of 5-year intervals would be more satisfactory, but that remains to be determined upon further evaluation and experimentation.

A reciprocal trend line was developed by the method of least squares for the same two groups. It was not necessary in this type of trend to assume any irreducible minimum, but it was necessary to use the reciprocal of some year as a basis of calculation. Therefore the rate for 1920 was arbitrarily used as the base. A decade of extrapolation was calculated by the two previous methods. Again it is possible that a shorter period of extrapolation may prove to be of greater value.

The use of one or more of these or similar techniques of evaluating traffic death rate trends might be used by enforcement agencies, transportation or insurance companies, and highway engineers in further appraising phases of their respective programs.

● TRAFFIC ACCIDENTS were responsible for 40 percent of all accident fatalities and 14 percent of all accident injuries in the U.S. during 1954 (3), and ranked first as the cause of death. An accident on the highway can generally be considered as an actual failure on the part of the road user, the vehicle, or the facilities concerned, in properly discharging their allotted functions in traffic movement (2). A study of the facts surrounding traffic accidents is of a vital concern to all those whose explicit purpose is reducing the resulting fatalities and injuries to a minimum. Only limited use has been made of the accumulated data on accidents to evaluate the various aspects of traffic control. The authors intend to suggest certain procedures whereby accident files may become more useful in this respect. Swanson (9) has made some explorations in this field.

Any safety program must be based on accurate reports and records that may be used for analysis in the prevention of traffic failures in the future. Such data if properly analyzed and used, would serve as a guide in a program of accident prevention for the many phases of traffic control improvement. No clear-cut methodology has so far been developed.

In the period of study ending in 1954, nearly 672,000 deaths and 23,500,000 nonfatal injuries have occurred in the nation as the result of motor vehicle accidents (4). Although the traffic death rates per 100 million vehicle miles of travel are decreasing, the absolute number of deaths and nonfatal injuries are on the increase, as is indicated from the number of licensed drivers, the number of vehicles registered, and the average annual mileage driven by individual drivers. These combine to give more vehicular miles being driven in greater traffic densities and at higher speeds.

During 1954, 36,000 fatalities and 1,250,000 nonfatal injuries with property damage of $1.6 billion were recorded for the U.S. Considering rates only, 1935 was the peak year for the two decades, with 15.9 fatalities per 100 million miles of vehicular travel. For the remaining period, deaths per unit of travel have been steadily decreasing, and a low traffic death rate of 6.4 fatalities per 100 million miles was reached in 1954. However, the absolute number of persons killed had reached a high of almost 40,000 with 1.4 million nonfatal injuries in 1941 (5). These data should be useful in evaluating the effectiveness of controls.

By determining trends, establishing the equations for best fitting curves, and extrapolating the curves, the expected number of fatalities can be predicted. If this method fails to show the expected results, a need for a change in the approach to the problem might be indicated.

Various factors should be taken into consideration. With a growing population and an increase in vehicle registration (as well as usage), trends can be better evaluated by comparison, when all factors are considered. The relationship of traffic deaths to vehicular miles during a given year seems to be the most widely accepted method of comparison. This acceptance is largely due to the greater validity of this index. The usage takes into consideration vehicle registrations and the mileage driven. Traffic density, population density, types of surfacing, enforcement policies, educational development, and other factors must be considered.

Trends and their extrapolations are based on deaths per 100 million vehicular miles of travel. However, the same techniques could be employed using the several other statistical data available.

Method of Procedure

The method used was that of collecting available accident and traffic data throughout the United States, organizing them into a systematic relationship, selecting the best fitting mathematical parameters and curves, and extrapolating these.

The trend curves were developed on traffic death rates for the 20-yr period 1935—1954. Extrapolations were made to the year 1970. The calendar year has been used in these calculations; thus, the study includes data from January 1, 1935, to December 31, 1954, with extrapolation to December 31, 1965. The rationale assumes a gradual evolutionary process of accident prevention development as well as the introduction of added hazards during the next 10 years.

Data on annual fatality rates per 100 million vehicle miles were obtained from several states, along with the U.S. rate, for the period. A great range in traffic death rates was found in various geographical areas.

Source of Data

The statistical data on the traffic death rate per 100 million miles vehicular travel were secured from the National Safety Council (6). The data as published listed individually the total number of traffic fatalities and the vehicular mileage traffic death rate for the U. S., for each state, and for the District of Columbia. A special study of data for Iowa in comparison with the U. S. only will be presented as an example of extension of the method to smaller geographical areas. The methods of trend extrapolations could be applied to any of the various states with the data presently available. Patrol districts or subdivisions of a state could be similarily studied to ascertain their relative standing and progress. Too often accident files are kept, and no practical use of the collected data is made.

TABLE 1

FATALITY TRENDS OF TYPICAL STATES

Year	Deaths per 100 Million Motor Vehicle Miles						
	U. S. Average	Conn.	Iowa	Mich.	Nevada	R. I.	Wash.
1935	15.9	14.1	11.5	16.7	26.0	6.6	17.7
1936	15.1	10.8	9.1	15.5	16.6	7.0	15.4
1937	14.7	9.7	9.5	15.9	13.9	7.0	12.5
1938	12.0	7.8	7.8	11.3	13.9	4.5	11.0
1939	11.3	7.6	8.1	11.2	14.5	3.8	9.9
1940	11.4	6.7	8.0	11.4	14.5	4.4	10.4
1941	12.0	7.5	8.2	12.5	16.9	4.6	12.0
1942	10.6	7.1	6.6	9.5	19.0	4.8	9.3
1943	11.5	8.0	6.4	9.4	16.0	5.9	9.8
1944	11.5	7.4	6.6	9.7	9.4	5.9	10.3
1945	11.3	7.1	6.5	9.7	15.0	6.6	12.6
1946	9.8	5.0	7.2	9.1	13.5	4.8	9.2
1947	8.8	4.4	7.3	8.2	11.9	4.8	7.6
1948	8.1	4.6	6.9	7.9	11.9	2.9	6.9
1949	7.5	3.4	6.4	7.2	9.8	3.0	5.8
1950	7.6	4.1	6.2	7.5	12.0	3.9	6.3
1951	7.5	4.0	6.2	7.2	12.1	3.0	6.3
1952	7.4	3.3	5.3	7.5	12.0	3.1	6.4
1953	7.1	3.7	5.8	7.5	10.6	2.9	5.2
1954	6.4	3.1	5.9	6.9	10.2	2.4	4.4

The purpose of this study is to suggest ways in which the extrapolation of such trends may be used to determine the effectiveness of any given program or programs designed to reduce traffic accidents. Sample best fitting trend curves are presented for the nation as a whole, and an index is suggested for use in evaluating trends of accidents in any state or geographical subdivision where data are available. The basic data are given in Table 1.

Analysis of Trends

The usual methods of trend analysis have been employed. Trend extrapolations have been determined by the method of least squares. The first attempt was made by assuming a linear trend. This leads to a fallacy of complete elimination of accidents about 1978. The assumption of a logarithmic curvilinear type of regression relationship was also tried since extrapolations were desired. From logical considerations, the trend cannot be less than some irreducible minimum. This was arbitrarily assumed to be ½ of the average death rate for the past 10 years. A reciprocal trend curve was calculated whereby it was unnecessary to assume such a minimum. The three types of time series trends were computed for the U. S. and Iowa.

Description of Trends in Fatality Rates

The fatality rates for Iowa, Connecticut, Rhode Island, Nevada, Washington and the

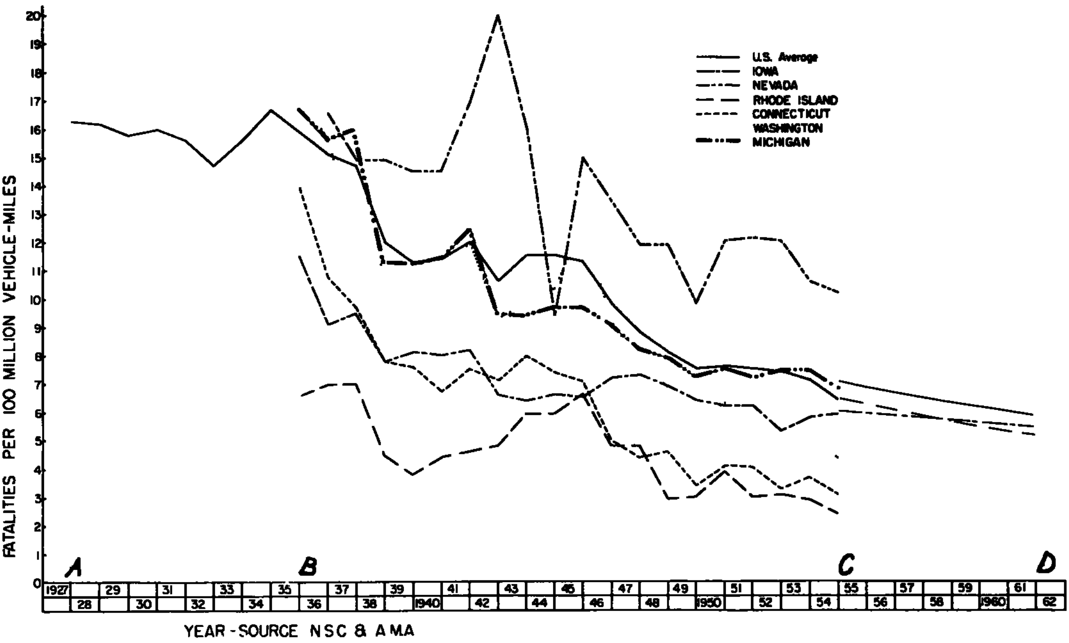

Figure 1. Deaths per 100 million motor-vehicle miles (compare with Table 2).

U. S. are given in Table 1, and Figure 1 was constructed from the data (7). Although the fatality rates per 100 million miles vehicular travel are included for the five states, trend analyses were computed only for Iowa and for the U. S. rates.

Linear trends. Any number of possible functions could be explored with respect to over-all trends in traffic death rates per 100 million miles vehicular travel. The first to be suggested is that any rate changes that take place constitute a linear function of time:

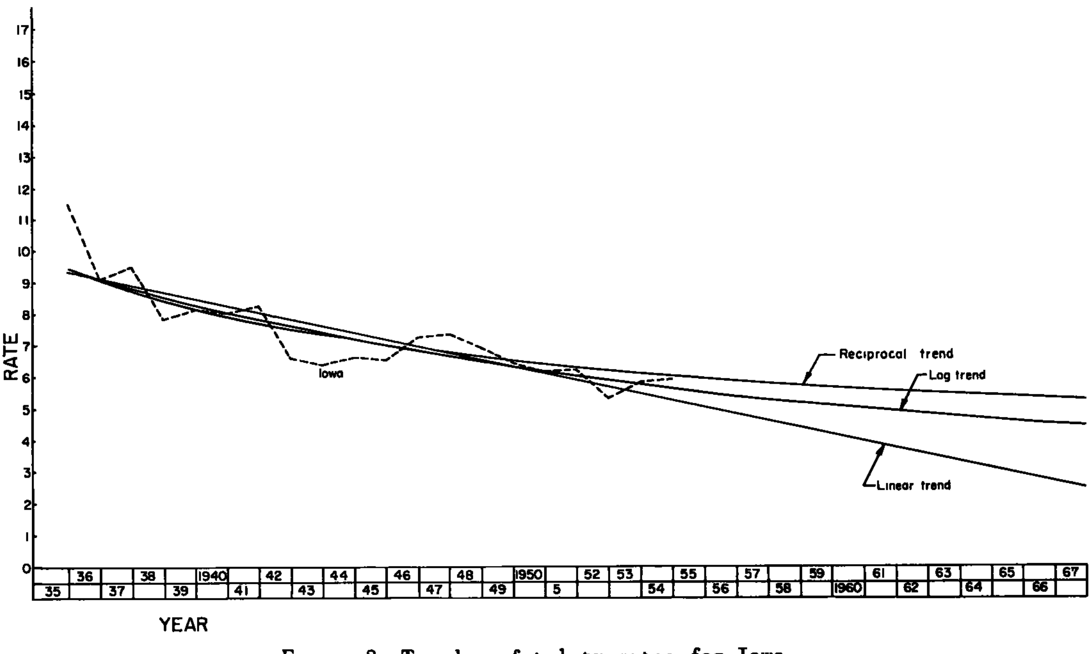

Figure 2. Trend in fatality rates for Iowa.

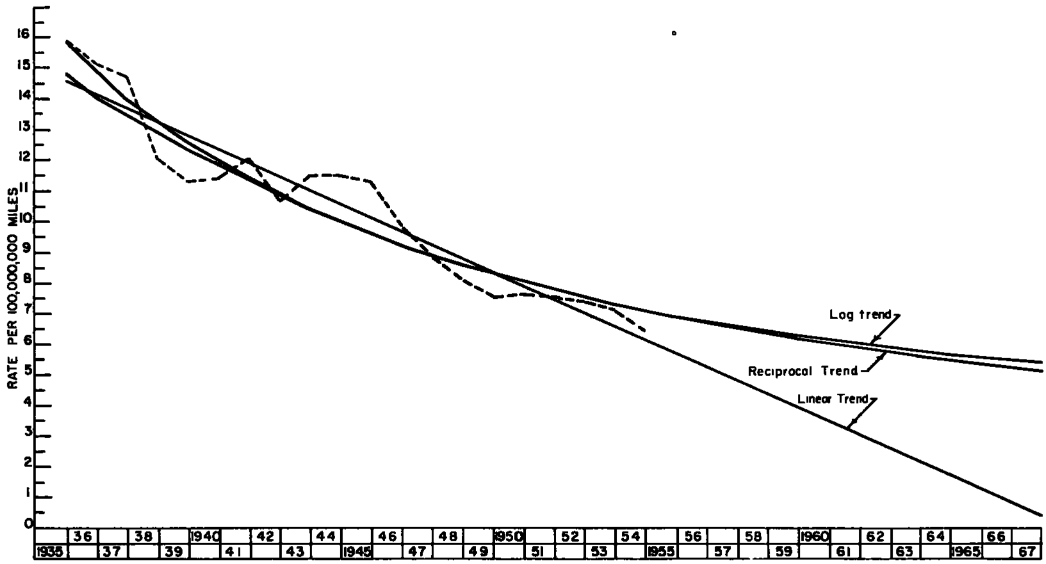

Figure 3. Trend in fatality rates for U.S.

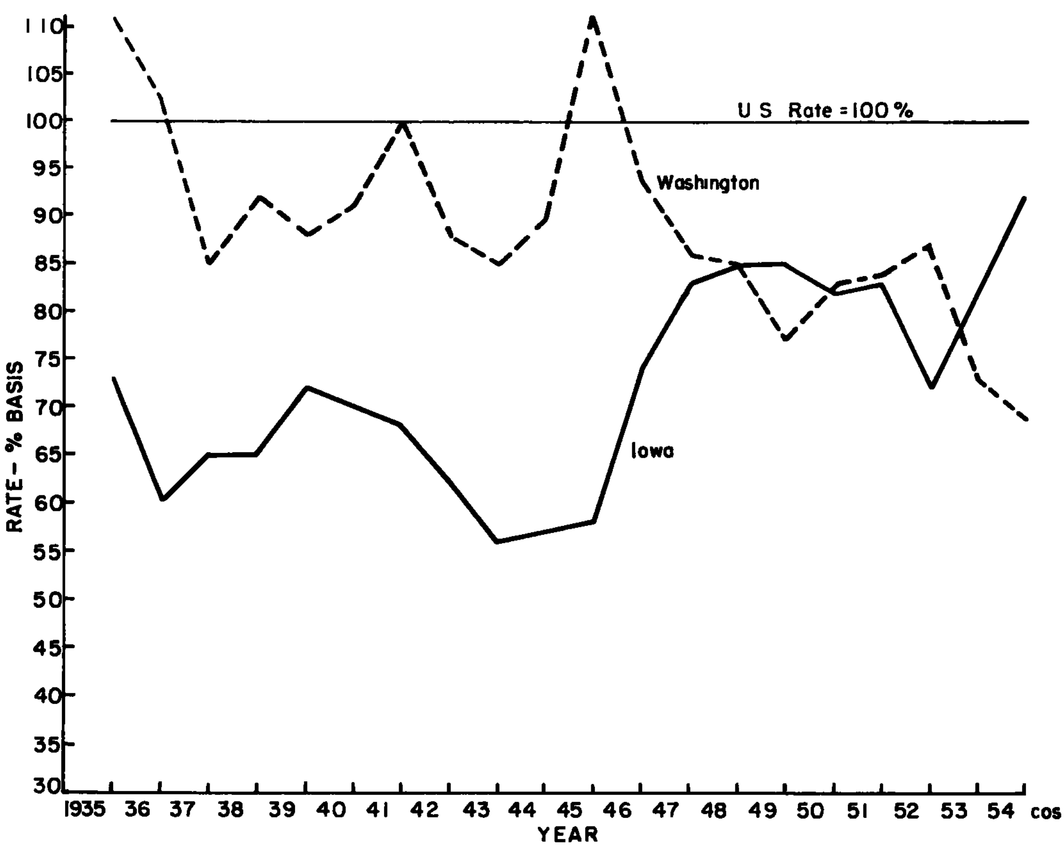

Figure 4. Fatality rates as a percentage of U.S. rate.

$$y = ax + k \qquad (1)$$

in which y = traffic death rate per 100 million vehicle miles travel;
x = twice the years removed from series middle 1944-45; and
a and k = constants.

A linear trend would reach zero about 1978 in Iowa and about 1968 for the U.S. From a rational point of view it was thought advisable to try some kind of curvilinear relationship which takes into consideration some irreducible minimum.

The determination of such an irreducible minimum must necessarily be somewhat arbitrary. For purposes of this study, one-half of the 10-yr average traffic death rate on a 100 million mile vehicular travel basis (1945-1954) was selected. For Iowa this value was 3.2 and for the U.S., 4.1. Thus, a trend equation asymtotic to 3.2 was used in computations concerned with Iowa:

$$\log (x - 3.2) = ax + k \qquad (2)$$

in which y = rate;
x = twice the years removed from series middle 1944-45; and
a and k = constants.

When the traffic death rate data for Iowa was substituted in the equations, values of a and k produced the logarithmic trend curves shown in Figures 2 and 3.

TABLE 2

ABSOLUTE NUMBER OF TRAFFIC DEATHS BASED ON EXTRAPOLATION TRENDS OF NUMBER OF VEHICLES, AVERAGE MILES PER VEHICLE, AND THE RECIPROCAL RATE

Year	No. of Vehicles (millions)	Av. Miles per Vehicle (thousands)	Reciprocal Trend Rate per 100 Million Vehicle Miles Travel	Absolute No. of Fatalities
1956	64	10	6.68	41,416
1957	66	10	6.49	42,834
1958	68	10	6.32	42,976
1959	70	10	6.16	43,120
1960	72	10	6.02	43,344
1961	74	10	5.89	43,438
1962	76	10	5.73	43,548
1963	78	10	5.61	43,758
1964	80	10	5.47	43,760
1965	82	10	5.37	43,870

Reciprocal trends. Reciprocal regression is a special form of the type of analysis indicated. If the exponent equals one, changes in y_1 are related reciprocally to changes in y_2. The normal equation by the reciprocal method of least squares has been selected:

$$y = \frac{a}{x} + k \qquad (3)$$

in which y_1 = year within the series;
y_2 = traffic death rate per 100 million miles vehicular travel;
x = twice the years removed from the series middle 1944-45; and
a and k = constants.

The resulting curves are shown in Figures 2 and 3. Table 2 has been prepared taking into consideration the number of vehicles and the average mileage estimated (1).

Other possibilities. Because each of these possibilities seems inadequate, the equation of a best-fitting curve might be used. The explorations made here are only suggestive of methods which could be used for evaluation of traffic control measures and policies.

By extrapolating the resultant curve for a 5- to 10-year period, a reasonable goal could be established against which to compare actual trends with a given speed law, enforcement policy, set of road conditions, or educational policy. For example, Michigan is just putting into effect a state-wide driver education program. The basic trend curve for Michigan is shown in Figure 1, with extrapolations from C to D. What might the fatality index be expected to be about five years hence? To single out systematic influences, as was done for Iowa and Washington, (Figure 4) for the next five years it should be possible to determine whether this program is substantially effective. Statistical methods are available for testing the significance of differences found at any given period of time. The same type of evaluation could be applied to sectional changes due to any type of treatment imposed and desired to be evaluated.

SUMMARY AND CONCLUSIONS

A method is proposed whereby accumulated accident data may be assembled to be of value in evaluating any set of conditions or program designed to reduce traffic accidents. The present paper is to be considered as exploratory in this field and many improvement and refinements will be made.

ACKNOWLEDGMENT

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